

# **LESSONS LEARNED FROM A UTILITY PROGRAM THAT MOVED TO A ZERO GWP ALTERNATIVE IN GAS INSULATED EQUIPMENT**

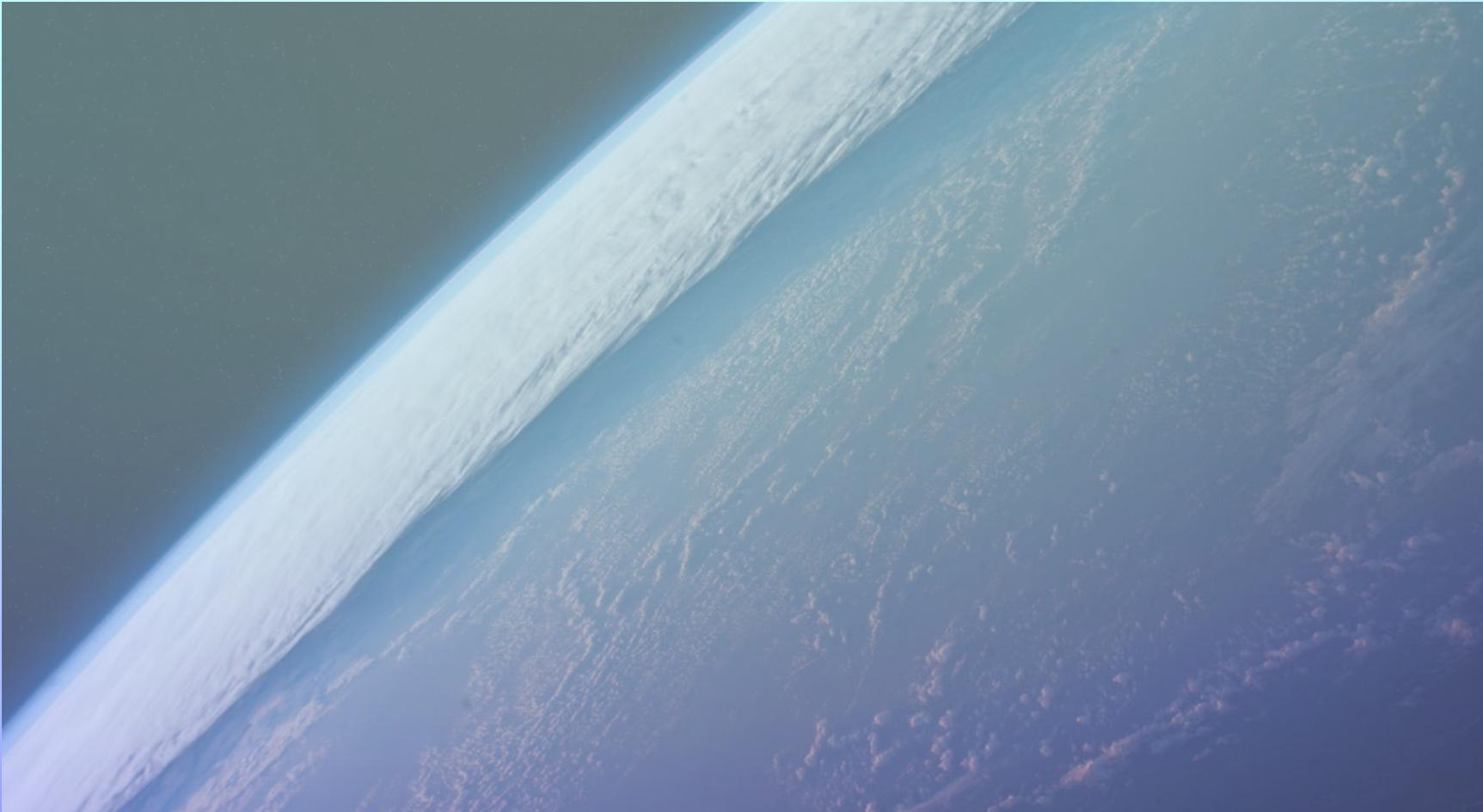
**LINUS FARIAS, CHMM**

**TOM RAK, PE**

**NET ZERO STRATEGIES**

“The climate is a common good, belonging to all and meant for all.”

~ Laudato Si [#23], 2015



# ABOUT NET ZERO STRATEGIES

- Utility-focused organization helping drive institutional change
  - Over 70 years of Engineering and Compliance experience
  - Change Management expertise
  - Designed utility-scale SF6 elimination program.

Linus Farias, CHMM

Principal

Environmental Policy and Compliance

Tom Rak, PE

Electric Utility Engineering and Standards Manager

# LESSONS LEARNED: *SPOILER ALERT*

1. ACTUAL SF6-GAS EMISSIONS SIGNIFICANTLY UNDER-REPORTED
2. SF6-GAS USE IS COSTLY, RISKY & A POOR ENVIRONMENTAL CHOICE
3. PROVEN ZERO-GWP SOLUTIONS ARE AVAILABLE TODAY
4. TRANSITIONING AWAY FROM SF6-GAS USE MAKES SENSE

# SF6 GAS INSULATED EQUIPMENT USES\*

Circuit Breaker

Switchgear

Power, Voltage  
& Current  
Transformer

Gas Insulated  
Lines

Capacitors

Gas-insulated  
Substations

\* SF6-gas also used in other utility applications not listed here.

# SF6-GAS PROPERTIES & EMISSIONS

## SF6-Gas

- Global Warming Potential: 23,500 (AR5, IPCC)
- Environmental Persistence: 3,200 years
- ‘Forever’ Gas in Atmosphere

## US Utility Emissions (CO2e, est.)

- 2016 SF6 emissions, EPA Partnership: 4.995 MMT
- 2016 SF6 emissions, EPA MRR: 7.57 MMT
- 1990-2021 SF6 total emissions reported: 510 MMT
- 2016 EPA Partnership GIE CO2e Reservoir: 117.39 MMT

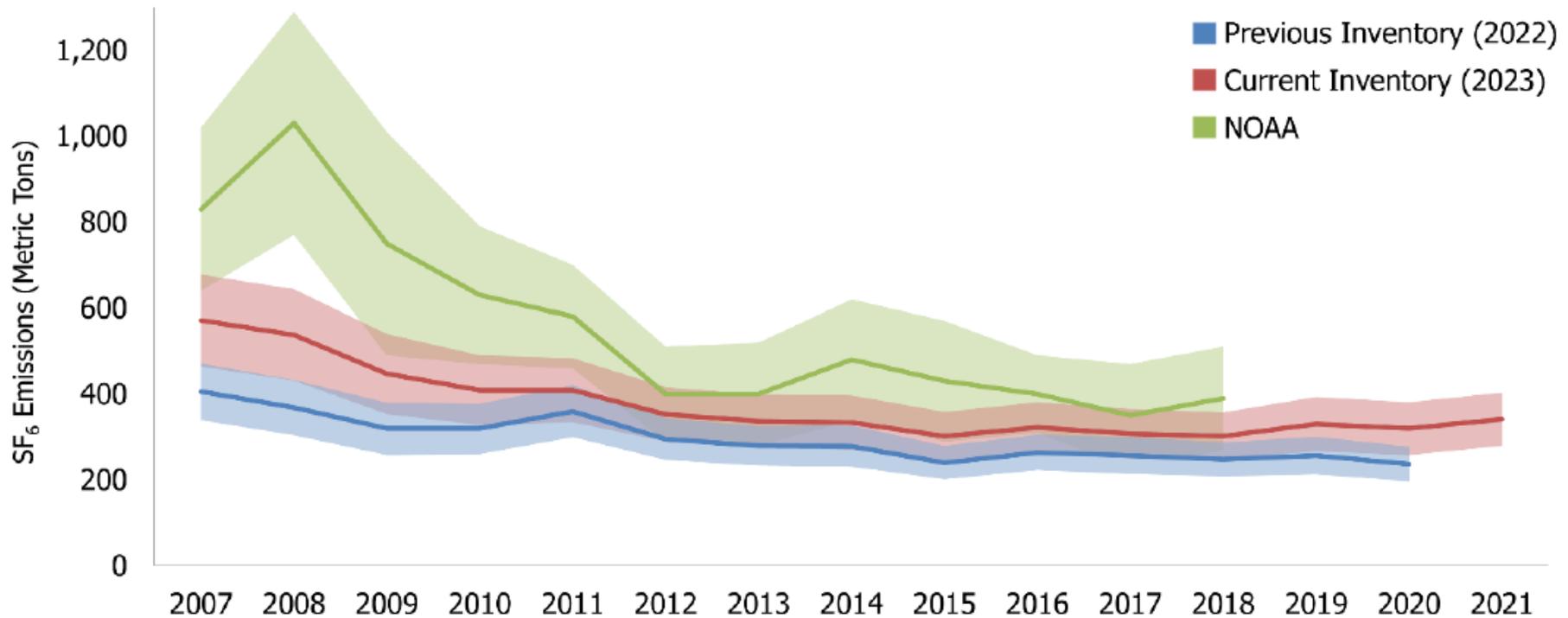
**SF6 emissions likely under-reported by > 50%  
(Top-down estimate, NOAA, 2023)**

**Lesson Learned: ACTUAL SF6-GAS EMISSIONS SIGNIFICANTLY UNDER-REPORTED**

# SF6-GAS PROPERTIES & EMISSIONS

USEPA (2023), USEPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2021

**Figure 4-3: U.S. Emissions of SF<sub>6</sub> Comparison<sup>a</sup>**



<sup>a</sup>Sources: NOAA data from Hu et al. 2022; EPA 1990-2020 inventory estimates from EPA 2022.

**Lesson Learned: ACTUAL SF6-GAS EMISSIONS SIGNIFICANTLY UNDER-REPORTED**

# WHY ELIMINATE SF6 FROM GAS INSULATED EQUIPMENT?

## MITIGATE RISK, REDUCE COST

- OPERATIONAL
  - Safety, Leak Management, Gas Supply
- COMPLIANCE
  - Increased Regulations, Data inaccuracies
- FINANCIAL
  - F-gas liability, Equipment Maintenance
- ENVIRONMENTAL
  - Highest GWP, Public Self-Reporting

**TWO CA UTILITIES FINED \$583,600 FOR INACCURATE REPORTING**

**Lesson Learned: SF6-GAS USE IS RISKY, COSTLY & A POOR ENVIRONMENTAL CHOICE**

# CALIFORNIA SF6-GAS ELIMINATION REGULATION

| Phase-Out Dates for SF6 GIE with Voltage Capacity $\leq 38$ kV |                       |                                   |                 |
|--|-----------------------|-----------------------------------|-----------------|
| Configuration  | Voltage Capacity (kV) | Short-Circuit Current Rating (kA) | Phase-Out Date  |
| Aboveground  | < 38                  | All                               | January 1, 2025 |
|  | 38                    | All                               | January 1, 2028 |
| Belowground  | $\leq 38$             | < 25                              | January 1, 2025 |
|  |                       | $\geq 25$                         | January 1, 2031 |

| Phase-Out Dates for SF6 GIE with Voltage Capacity > 38 kV |                                   |                 |
|---|-----------------------------------|-----------------|
| Voltage Capacity (kV)                                     | Short-Circuit Current Rating (kA) | Phase-Out Date  |
| 38 < kV $\leq 145$  | < 63                              | January 1, 2025 |
|   | $\geq 63$                         | January 1, 2028 |
| 145 < kV $\leq 245$                                       | < 63                              | January 1, 2027 |
|   | $\geq 63$                         | January 1, 2031 |
| > 245   | All                               | January 1, 2033 |

CARB SF6 Phase-out schedule

Supported by:

- California Utilities
- Several OEMs

**Lesson Learned: CALIFORNIA HAS A DEFINED PATH TO ZERO GWP**

# CALIFORNIA SF6-GAS ELIMINATION REGULATION: OEM RESPONSE

Zero-GWP equipment available: GIS, LTCCB, DTCCB, VCB, Instrument Transformer

Meiden USA – 72kV, 145kV

Siemens - 72kV, 145kV, 245kV, 420kV

MEPPI – 72kV, 245kV

Toshiba – 72kV

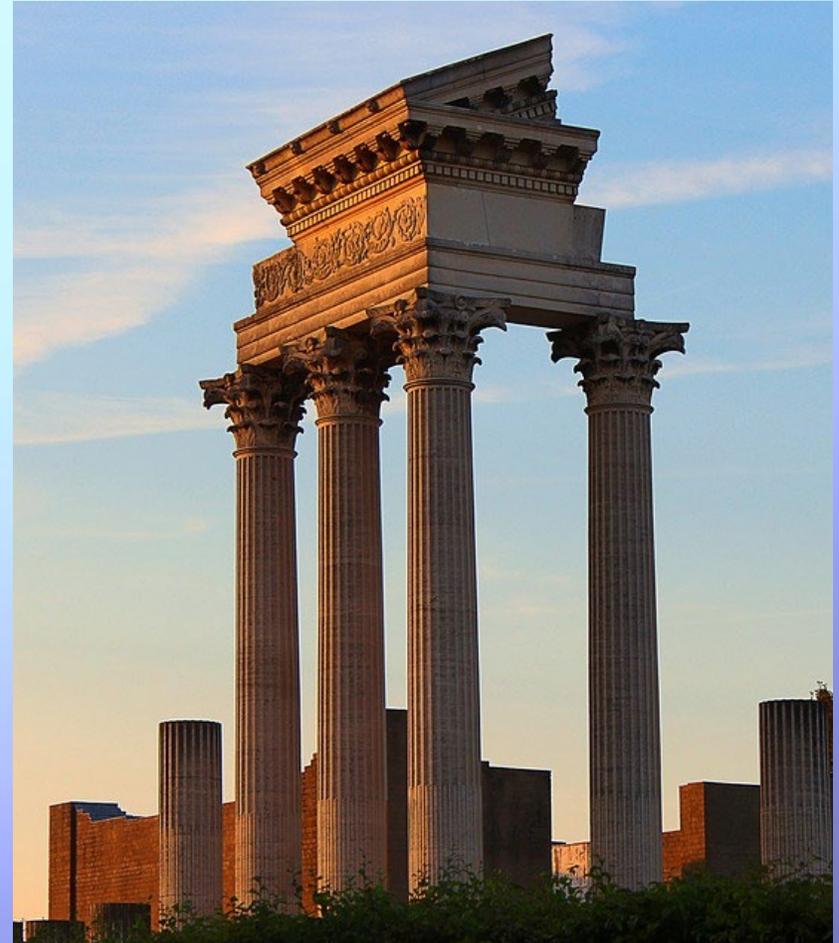
Nuventura – 36kV

Other Suppliers - <38 – 245kV

**Lesson Learned: PROVEN ZERO-GWP SOLUTIONS ARE AVAILABLE**

# PILLARS FOR ZERO-GWP SUCCESS

1. SF6 Phase-Out Charter & Commitments
2. Systemwide Audit to establish a Baseline
3. Roadmap to Zero



# PILLAR 1: SF6 PHASE-OUT CHARTER & COMMITMENTS

Corporate Charter with commitment to Eliminate SF6-gas use:

## Commitments

1. Establish equipment Phase-out schedule by Switchgear Class
2. Procure & install only zero-GWP equipment within 10 years
3. Procure SF6-GIE that leaks  $\leq 0.3\%$
4. Implement Aggressive SF6-management program
5. Adequate, multi-year funding to meet Charter & Commitments

**Lesson Learned: A CLEAR CHARTER GUIDED EFFECTIVE ACTION**

# PILLAR 2: SYSTEM AUDIT

## Scope: *Program Review, Assessment and Evaluation*

- Audit Program Awareness
  - Roles & Responsibilities, Training Programs
- Audit Documentation
  - Policies, Standards, Procedures, Equipment Specifications & Guidance
- Audit Field Work Practices
  - Leak Detection & Repair, Cylinder Management, Emergency Response
- Audit Technology & Management Systems
  - Recordkeeping and Reporting Tools

**Lesson Learned: AUDIT IDENTIFIED SYSTEM GAPS, FOUNDATION FOR PROGRAM IMPROVEMENTS**

# PILLAR 3: ROADMAP TO ZERO

## REVISE GAS INSULATED EQUIPMENT DOCUMENTATION

- Update Equipment Specifications and Related Documentation

## PROCURE ZERO GWP EQUIPMENT

- Zero-GWP Switchgear Procurement Standards
- Project Planning
- Training & Awareness
- Technical Waivers for SF6 or non Zero-GWP alternatives

## CREATE ZERO-GWP UTILITY WORKGROUP

- Utility-OEM forum to benchmark & support

# PILLAR 3: ROADMAP TO ZERO (*contd.*)

## MANAGE ACTIVE GAS INSULATED EQUIPMENT

- Active Leak Survey, Detection & Repair program
- Implement Nameplate Accuracy procedures
- Monitor & Repair Leaks

## CONTROL SF6-GAS USE & CYLINDERS

- Use Recycled SF6-gas
- Implement Best Management Practices for Cylinder & Gas-handling

## TRACK PROGRESS

- Quarterly Performance Reports – GIE leaks, Cylinder management
- Benchmark Program Performance with peer utilities
- Communicate Lessons & Challenges with regulators, as appropriate

# ROADMAP TO ZERO: LESSONS LEARNED

## ZERO-GWP EQUIPMENT

- Equipment design did fit existing building footprint
- Working *with* suppliers helped drive specifications & schedule
- Zero-GWP equipment is cost-neutral or cheaper than SF6 GIE
- Utility workgroup, OEMs drove industry change & Phase-out schedule

## SF6 GAS INSULATED EQUIPMENT

- Purchase equipment with leak rate  $\leq 0.3\%$
- Test and manage leaks irrespective of GIE age and size
- Establish Centralized Cylinder Management program
  - *Reduce cylinder inventory*
  - *Use recycled SF6-gas exclusively*

# KEYS TO SUCCESSFULLY TRANSITION TO ZERO-GWP

1. Establish a SF6 Phase-out Charter with Commitments to Guide Effective Action
2. Perform a System Audit to Identify Gaps & Set a Foundation for Program Improvement
3. Execute Road-map to Mitigate Risk, Reduce Cost & Liability
  - TRANSITION to Zero-GWP solutions
  - MANAGE SF6 GIE
4. Collaborate with like minded utilities

# QUESTIONS?

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Photo: NASA Earth Images